objects in which real nebulæ are distinctly associated with the above diffused nebulosity.

3. *Detached nebulosities.*—He next mentions six cases in which, instead of the extensive diffusion referred to under the first head, the nebulosity is found detached.

4. *Milky nebulæ.*—He here remarks that when detached nebulosities are small we are used to call them nebulæ, and he shows that the nebulosities and the nebulæ, whatever may be their appearance, as well as those expressly called by him "milky," partake of the same general nature.

5. *Milky nebulæ with condensations.*—He refers to the brightest portions of the nebula in Orion as an indication of what he means by condensation; then to another in which the greatest brightness lies towards the middle; and then he adds:—"By attending to the circumstances of the size and figures of this nebula we find that we can account for its greater brightness towards the middle in the most simple manner by supposing the nebulous matter of which it is composed to fill an irregular kind of solid space, and that it is either a little deeper in the brightest place, or that the nebulosity is perhaps a little more compressed. It is not necessary for us to determine at present to which of these causes the increase of brightness may be owing; at all events it cannot be probable that the nebulous matter should have different powers of shining, such as would be required independent of depth or compression" (p. 282).

6. *Nebulæ which are brighter in more than one place.*—He associates the general swelling of the nebulous matter about the places which appear like nuclei with the unequally bright places in the diffused nebulosities, and further on he refers to universal gravitation "as a cause of every condensation, agglomeration, compression, and concentration of nebulous matter."

7. *Double nebulæ with joining nebulosity.*—He points out that "in fifteen objects two nuclei or centres of attraction have been observed, and that if the active principle of condensation carries on its operation a diffusion of their at present united nebulosities must in the end be the consequence" (p. 285).

8. *Double nebulæ not more than 2′ from each other.*—He points out that there are twenty-three of this class.

9. *Double nebulæ at a greater distance than 2′ from each other.*—Of these he gives a hundred examples, pointing out that "there are not more than five or six which differ so much in brightness from one another that we can suppose them to be at any very considerably different distance from us" (p. 288), and he further adds that "equal brightness or faintness runs through them all in general."

10. *Treble, quadruple, and sextuple nebulæ.*—He refers to twenty treble, five quadruple, and one sextuple object of each kind.

11. *Very narrow long nebulæ.*
12. *Extended nebulæ.*
13. *Irregular nebulæ.*
14. *Nebulæ that are of an irregular round figure.*
15. *Round nebulæ.*
16. *Nebulæ that are remarkable for some peculiarity of figure or brightness.*—He ascribes this irregularity to the as yet imperfect concentration of the nebulous mass in which the preponderating matter is not in the centre (p. 300).
17. *Nebulæ that are gradually a little brighter in the middle.*
18. *Nebulæ which are gradually brighter in the middle.*
19. *Nebulæ that are gradually much brighter in the middle.*
20. *Nebulæ that are suddenly much brighter in the middle.*
21. *Round nebulæ increasing gradually in brightness up to a nucleus in the middle.*
22. *Nebulæ that have a nucleus.*
23. *Round nebulæ that show a progression of condensation.*
24. *Round nebulæ that are of an almost uniform light.*
25. *Nebulæ that have a cometic appearance.*
26. *Extended nebulæ that show the progress of condensation.*
27. *Nebulæ that draw progressively towards the period of final condensation.*
28. *Planetary nebulæ.*

In addition, Sir William Herschel in his various papers gives drawings illustrating the classification which has been above referred to (Phil. Trans., vol. ci. Plates 4 and 5, and vol. civ. Plate 11). A more elaborate set of plates illustrating the various gradations of the different forms will be found accompanying Sir John Herschel's catalogue (Phil. Trans., vol. cxxiii., 1833, Plates 9, 10, 11, 12, and 13). In these illustrations will be found some forms of great interest not referred to by the elder Herschel. Long parallel nebulæ, for instance, with a dark streak separating them, and elliptic and ring nebulæ. With these exceptions, all the illustrations readily fall into Sir William Herschel's classification.

In the valuable paper of Sir John Herschel, to which reference has been made, there is evidence to show that he gives up the idea of nebulous matter distinct from stars advocated by his father. He says: "If the nebula be anything more than a cluster of discrete stars, as we have every reason to believe, at least in the generality of cases, no pressure can be propagated through it" (Phil. Trans., 1833, vol. cxxiii. p. 502). Coming down to the work of Lord Rosse, we find that as early as 1846 he had convinced himself almost completely that no such thing as so-called nebulous fluid existed. In a letter to Nicol ("Architecture of the Heavens," p. 143) under date March 19, referring to the nebula of Orion, he states that he could "plainly see that all about the trapezium is a mass of stars, the rest of the nebula also abounding with stars and exhibiting the characteristics of resolvability strongly marked."

The magnificent observations of the nebulæ made by Lord Rosse will be found in the Philosophical Transactions (R. S.) for the years 1850 and 1861, the latter giving an account of the work done by the 6-foot, and in the Scientific Transactions of the Royal Dublin Society for 1880. In the volume for 1861, p. 702, Lord Rosse seems rather inclined to withdraw the very definite letter which has been previously quoted, and states that, "When the letter R, meaning that the nebula is resolvable, has been used, he does not attach much importance to the expression of opinion it conveys, because the question of resolvability can only be successfully investigated when the air is steady and the speculum is in fine order."

This state of uncertainty, however, did not last long, for in 1864 Dr. Huggins and Dr. Miller demonstrated that the spectrum of several planetary and other nebulæ which they examined, instead of giving spectra like those of the stars, gave one of bright lines, one of the lines being due, as they asserted at the time, to hydrogen; the other, as it lay very near a line of nitrogen, was supposed by them to represent "a form of matter more elementary than nitrogen, and which our analysis has not yet enabled us to detect" (Phil. Trans., 1864, p. 444). Then they wrote:—"It is obvious that the nebulæ (that they had examined) can no longer be regarded as agglomerations of suns after the order to which our sun and the fixed stars belong. We have in these bodies to do no longer with a special modification only of our own type of suns, but find ourselves in the presence of bodies possessing a distinct and separate plan of structure."

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE forty-second annual general meeting of the Institution of Mechanical Engineers took place at 25 Great George Street, Westminster, by permission of the Council of the Institution of Civil Engineers, on January 30 and 31, and February 1, the President, Mr. Charles Cochrane, in the chair.

The three papers down for reading and discussion were: supplementary paper on the use of petroleum refuse as fuel in locomotive engines, by Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, South-East Russia; on compound locomotives, by Mr. R. Herbert Lapage, of London; on the latest development of roller flour milling, by Mr. Henry Simon, of Manchester.

The author of the first paper states that his object is to bring before the Institution the more recent results of his experience in the use of petroleum refuse as a locomotive fuel, now being used on an unprecedented scale on the Grazi and Tsaritsin Railway. Since the publication of the original paper in 1884, nothing new in principle has been discovered, and the same appliances have been used, having undergone very slight modifications, dictated by experience and constant observation. The whole of the 143 locomotives under the author's superintendence, as well as various stationary boilers of various types, have been fired with petroleum refuse, to the complete exclusion of all solid fuel, as well as in all the heating furnaces at the Company's Central Works at Borioglebsk. The petroleum refuse is burnt in the form of a spray, being blown into the furnace against a brick structure, serving the double purpose of a reservoir for the heat, and against which the spray is broken up. Many experiments were made with a variety of forms of

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brickwork inside the furnace or fire-box, which are duly described by the author. The spray-injector is of course illustrated. On this depends the efficient working of the furnace. The oil is blown into the furnace by means of a steam jet. Experiments have been made on the use of compressed air instead of steam; and, from what could be observed during a two months' trial, the complication and cost of the extra gear would not be recouped by a sufficient economy in fuel consumption. The effect of petroleum fuel on the boilers, after five years' experience, appears to be less destructive than when firing with anthracite, which is particularly destructive to the fire-boxes and tube-ends. The author states that the petroleum flame produces in reality no more detrimental effect on the fire-box and tubes than a wood flame, owing to the protection afforded to the more important parts by the fire-brick lining; moreover, petroleum refuse contains no sulphur, which is so prevalent in all coals, and so injurious to the metal of the fire-box and tubes. The evaporative value of petroleum refuse appears to be very high. With an effective steam pressure of 125 pounds per square inch, the highest evaporative duty of the fuel in the author's locomotives has been 14 pounds of water per pound of fuel, in comparison with the theoretical evaporative value of 17·1 pounds. The actual efficiency of the fuel is therefore nearly 82 per cent., the tables giving an evaporation, under the same conditions, for good English coal, of 12·16 pounds of water.

Mr. Urquhart's paper will be read with great interest by those following his example in using various oils and tar as a fuel for locomotives and stationary boilers. Provided a cheap source of fuel in the form of petroleum refuse or oil can be relied upon, the many reasons for raising steam in this way are obvious, to say nothing of the possibility of the machinery being kept free from all the dirt necessitated by the use of coal on a locomotive.

The object of the paper on compound locomotives, by Mr. R. Herbert Lapage, is to furnish an account of some recent practice in designing and working two-cylinder compound locomotives. The advantages of compounding—that is, expanding the steam in more than one cylinder—is due to the difference of temperature between the boiler steam and the exhaust being distributed over two cylinders, with the important result that there is not so much difference as in the ordinary locomotive between the temperature at the beginning and that at the end of the stroke in each cylinder; consequently there is less initial condensation and less re-evaporation of condensed steam, and a more uniform pressure on the pistons throughout the stroke; and owing to the more constant and even pressure on the pistons, the turning moments about the driving axle are more uniform, giving less sudden strains to the machinery generally, thereby increasing the life of the machine. The fact that so little attention has until recently been paid to the compounding of locomotives appears to be owing to there having hitherto been considerable complication of parts, in connection both with obtaining a simple device for starting the engine and of equalizing the power developed in the high and low pressure cylinders. These objections have now been thoroughly overcome in what is known as the Worsdell and Von Borries system, in which the two-cylinder compound locomotive has been brought to a high pitch of efficiency. The author of the paper describes a six-wheel-coupled goods engine which was sent out in 1886 to the Entre-Rios Government Railway, having been built by Messrs. Dubs and Co., Glasgow. This engine was built on the compound principle, after investigating the excellent results obtained by the Worsdell and Von Borries system. The dimensions of the cylinders are—high pressure, 16 inches diameter; low pressure, 23 inches; both cylinders having a stroke of 24 inches; the working pressure being 175 pounds per square inch; diameter of driving wheels 3 feet 9 inches. The total weight in working order is 37 tons, probably having about 30 tons useful weight for adhesion; the cut-off of the valves in ordinary running being in the high pressure cylinder 40 per cent., and in the low pressure 50 per cent. Various trial trips were made with this compound on the Caledonian Railway, the work done without doubt showing the power and efficiency of the engine. In the locality where this engine is working coal costs at least £2 a ton; presuming an ordinary engine runs 30,000 miles a year at 25 pounds of coal per mile, it will have burnt 335 tons, which, at £2 per ton, costs £670. The compound, effecting a saving of about 20 per cent., will accordingly save £134 in a year. It is found that a compound locomotive of less weight can haul as heavy a train at the same speed as an ordinary engine, provided the adhesion is sufficient, with the economy of from 14½ to 20 per cent., and as the cost of the compound is no greater than such an engine, the 20 per cent. or £134 per year saved is a net saving to the engine. Compound express locomotives working the heaviest service, which run about 3000 miles per month, are found to do some 15 per cent. more mileage between shop repairs than the ordinary engines of the same size and class.

The fact that two important papers should have been read before the Institutions of Civil and Mechanical Engineers respectively points to the conclusion that the compound locomotive has out-grown the experimental stage. Mr. Lapage says nothing in his paper about the "Webb" system, and probably this is a sign of the "survival of the fittest." The Worsdell engine requires little, if any, alteration in the primary parts of an ordinary engine. The number of working parts is not increased, and the strains set up in the engine are more uniform and less intense than in the ordinary engine, less steam is used, and therefore the boiler is not worked so hard—in fact, everything in connection with the working of these engines points to less general wear and tear of parts, and therefore longer life to the machine.

The last paper on the list, on the latest development of roller flour milling, by Mr. Henry Simon, deals with the extraordinary revolution which, during the last ten years, has been in progress in the manufacture of flour by the substitution of the roller system for the ancient method of grinding by stones; and the object of the present paper is to give further information about the subsequent development of roller flour-milling as carried out by the author. The completeness of the revolution that has taken place is exemplified by the fact that practically, in less than ten years, the machinery and methods of corn milling have been radically and entirely altered at the cost of an immense amount of capital. The millstone, dating from prehistoric times, has been almost entirely discarded, and the miller has been constrained to unlearn the old methods, and take up one entirely new, based upon very different principles. The first complete roller-mill, without the use of stones, in England, was built by the author in 1878 for Mr. Arthur McDougall, of Manchester, and in Ireland for Messrs. E. Shackleton and Sons in 1879; the first automatic roller flour-mill in England in 1881 for Messrs. F. A. Frost and Sons, Chester. The total number of complete mills, or important reconstructions of old mills, executed by the author since 1878 amounts to considerably more than 200, varying in cost for machinery, exclusive of motive power, buildings, &c., from £1000 to £40,000 for each mill.

As it is nearly impossible to give our readers an adequate description of this class of machinery without diagrams, we do not attempt the task, but recommend Mr. Simon's very interesting paper to the careful perusal of all practical millers.

NOTE ON THE ACTION OF ACIDS UPON ULTRAMARINE.

At the Birmingham meeting of the British Association in September 1886, I read a short paper "On the Fading of Water-colours." This was published in the *Chemical News*, vol. liv.

Observation and experiments had led me to the conclusion that water-colour drawings in which ultramarine was mixed with reds for the representation of purple and gray tints such as are seen when viewing distant mountains, the shadows of clouds, and other luminous shadows, the colours are liable to suffer from the action of acids such as might be found in the drawing-paper, or in the damp atmosphere of towns where much coal is burnt. The general opinion of artists is one which I believe does not coincide with this view. The same series of experiments had shown that under ordinary circumstances indigo was a colour of great stability compared with many other pigments, and this again was in conflict with the experience of artists. It is not impossible to explain how we have arrived at such different views, and though it would be inconvenient to enter into an explanation in full, it may be considered as within the scope of this paper to record the fact that the colours were washed upon the best drawing-paper, dried in a subdued light, and not exposed to the conjoint action of damp and sunlight.

The matter in hand is the question of the stability of ultramarine in presence of acids. In an old work by M. Constant de Massoul, translated into English in 1812, entitled "A Treatise on the Art of Painting and the Composition of Colours," a short

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